Simultaneous Over- and Underconfidence: Evidence from Experimental Asset Markets[*]

Boris Maciejovsky[‡], Erich Kirchler[§]

June, 2001

Abstract

In this paper individual overconfidence within the context of an experimental asset market is investigated. Overall, 72 participants traded one risky asset on six markets of 12 participants each. The results indicate that individuals were not generally overconfident. Moreover, overconfidence was found to be moderated by the methodology used. Participants were well-calibrated as well as over- and underconfident during some trading periods with respect to the accuracy of their predictions, while their subjective confidence intervals were generally too narrow and overconfidence was found to increase with experience.

Keywords: Overconfidence; Financial Markets; Experimental Economics

JEL-Classification: C90; D40

---

[*] The authors acknowledge financial support by the University of Vienna under the project title "600 Jahre Universität Wien". Thanks are due to Tarek El-Sehity, Eva Hofmann and Herbert Schwarzenberger, who have helped to run the experiment at the University of Vienna. Valuable comments by Werner Güth, Manfred Königstein, Rupert Sausgruber, Reinhard Selten and Erik Theissen, and by seminar participants at the Centre for Interdisciplinary Research (ZiF) at the University of Bielefeld, at the Humboldt-University of Berlin, and at the IAREP/SABE-conference 2000 in Baden/Vienna are gratefully acknowledged.

[‡] Humboldt-University of Berlin, Department of Economics, Institute for Economic Theory III, Spandauer Strasse 1, D-10178 Berlin, Germany. Tel. +49/30/2093-5790, Fax. +49/30/2093-5704, e-mail: maciej@wiwi.hu-berlin.de

[§] University of Vienna, Department of Psychology, Unit of Economic Psychology, Universitaetsstrasse 7, A-1010 Vienna, Austria. Tel. +43/1/4277-47880, Fax. +43/1/4277-47889, e-mail: erich.kirchler@univie.ac.at

Financial support was received by the Deutsche Forschungsgemeinschaft, SFB 373 ("Quantifikation und Simulation Ökonomischer Prozesse"), Humboldt-Universität zu Berlin.

1. Introduction

Psychological evidence on individual decision biases and heuristics challenges the prescriptive predictions of standard finance theory which is still the dominant paradigm in modern finance. In particular, it doubts the validity of the rationality axiom. One violation of standard finance theory is the overconfidence bias which refers to the systematic over-estimation of the accuracy of one's decisions and to the overestimation of the precision of one's knowledge.

Most of the psychological evidence supporting the overconfidence bias is, however, based on questionnaire studies involving only hypothetical decision tasks with no financial consequences to the decision maker. In addition, recent empirical studies indicate that individuals are not *generally* overconfident (e.g., Klayman, Soll, Gonzalez-Vallejo and Barlas, 1999). Moreover, the overconfidence bias has been reported to be moderated by the methodology used (e.g., Erev, Wallsten and Budescu, 1994). Yet, overconfidence has been extended and successfully applied to financial decision making and to investment behavior, both theoretically (e.g., Benos, 1998; Odean, 1998) as well as empirically (e.g., Barber and Odean, 2000; Odean, 1999). However, little work has been done to study the overconfidence bias in financial decision making experimentally. In this paper we investigate the overconfidence bias within the context of an experimental asset market allowing for competition and learning to take place. Participants do not make hypothetical decisions, but are paid according to their decisions.

The balance of the paper is organized as follows: In section 1.1 empirical evidence on the overconfidence bias is discussed, in section 1.2 literate about unrealistic optimism is reviewed, and in section 1.3 both are combined in order to discuss their implications especially with respect to financial decision making. Section 2 deals with the hypotheses, and section 3 is concerned with the experiment, the participants, the design, and the procedure, whereas in section 4 the results are presented which are eventually discussed in the closing section 5.

1.1 Overconfidence

Overconfidence is considered the most robust finding in the psychology of judgment (e.g., De Bondt and Thaler, 1995). It refers to the systematic overestimation of the accuracy of one's decisions, and has been observed in many professionals, for instance in clinical psychologists (Oskamp, 1965), engineers (Kidd, 1970), entrepreneurs (Cooper, Woo and Dunkelberg, 1988), investment bankers (Stael von Holstein, 1972), lawyers (Wagenaar and Keren, 1986), managers (Russo and Schoemaker, 1992), negotiators (Neale and Bazerman, 1990), and physicians and nurses (Christensen-Szalanski and Bushyhead, 1981). In addition, empirical results indicate a gender effect: Females were found to be less overconfident than men (Pulford and Colman, 1997).

Overconfidence was found to be strongest for questions of moderate to extreme difficulty (Fischhoff, Slovic and Lichtenstein, 1977; Griffin and Tversky, 1992; Lichtenstein, Fischhoff and Phillips, 1982; Soll, 1996; Yates, 1990), and seems to increase with the personal importance of the task (Frank, 1935). Schraw and Roedel (1994) showed in an experimental investigation that overconfidence is due largely to test difficulty, and Juslin (1993; 1994) found that overconfidence is eliminated when test items are selected randomly. However this result could not be confirmed by Brenner, Koehler, Liberman and Tversky (1996). Stone

(1994) reported that self-efficacy judgments made in cognitively complex tasks are biased toward overestimates of personal ability, such as overconfidence.

When easy judging tasks are involved, empirical results indicate that individuals may even be underconfident (Klayman, Soll, Gonzalez-Vallejo and Barlas, 1999; Pulford and Colman, 1997). Subbotin (1996) investigated the effect of outcome feedback on over- and underconfident judgments in a general knowledge task. His results indicate that outcome feedback reduces the bias and improves calibration of underconfident judgments, but has no effect in the case of overconfident judgments. People were also found to be more confident of their predictions in fields where they have self-declared expertise (Heath and Tversky, 1991).

Plous (1995) compared interval overconfidence with respect to individual tasks and to group tasks. The results indicate that 3-4 person nominal groups, who were not allowed to interact, were found to be more accurate in their judges than individuals. Yet, comparing individual judges to judges made by interacting group members indicate that such groups did not perform substantially better than individuals, although participants frequently had the impression they would. There is also evidence of stability of overconfidence across domains. West and Stanovich (1997) report a positive correlation between participants' degrees of overconfidence in their performance on a general knowledge task and on a motor skill task, and Bornstein and Zickafoose (1999) report stability between the domains of eyewitness memory and general knowledge. Perfect and Hollins (1996) found that participants were equally overconfident in both domains, their performance in an eyewitness task and in a general knowledge task. However, the authors did not assess the stability of overconfidence on an individual level.

Overconfidence has been explained by selective information searching strategies (e.g., Hoch, 1985; Klayman, 1995; Koriat, Lichtenstein and Fischhoff, 1980), by motivational factors (e.g., Babad 1987; Kunda, 1990; Langer, 1975; Larrick, 1993), by imperfections in learning (e.g., Erev, Wallsten and Budescu, 1994; Ferrell, 1994; Soll, 1996), and for instance by the experimenters' tendency to choose harder-than-normal questions (e.g., Gigerenzer, Hoffrage and Kleinbölting, 1991; Juslin, 1993, 1994).

Overconfidence can also be defined with respect to subjective confidence intervals. When investors are asked to generate price forecasts p_{lo} and p_{hi}, so that there is only an x% chance that the future price will be lower than their price prediction p_{lo}, and an x% chance that the future price will be higher than their price prediction p_{hi}, the observed intervals are often too narrow. Whereas, the expected price predictions should create a confidence interval with a range of (100 - 2x)%, the observed intervals actually only cover some of the predicted range. In a study conducted by Lichtenstein, Fischhoff and Phillips (1982), subjects were asked to create a subjective confidence interval of 98% width. The actual proportion of intervals that failed to include the true answer, however, equaled 42% rather than 2%. Subjects in the study of Yaniv and Foster (1997) had to create a subjective confidence interval of 95% width, and observed intervals of 55% width. Subjective confidence intervals were thus too narrow as they excluded the correct answers far too often.

Exceptions to overconfidence are reported (i) for tasks where predictability is high, (ii) for tasks where swift and precise feedback about the accuracy of the judgments is provided, and (iii) for highly repetitive tasks (Kahneman and Riepe, 1998). Correspondingly, expert bridge players (Keren, 1987), race-track bettors (Dowie, 1976; Hausch, Ziemba and Rubinstein, 1981), and meteorologists (Murphy and Winkler, 1984) were found to be well-calibrated in their predictions.

1.2 Unrealistic optimism

Empirical evidence suggests that individuals do not only overestimate the accuracy of their knowledge, but also tend to be unrealistically optimistic about their future (Weinstein, 1980). Weinstein (1984) conducted a study on 405 students to examine their perceptions of susceptibility to health and safety risks. Whereas subjects were generally unbiased about hereditary risk factors and were even somewhat pessimistic about environmental risk factors, they were excessively optimistic in their views of their own actions and psychological attributes. Weinstein (1987) found that hazards most likely to elicit unrealistic optimism are those associated with the belief that if the problem has not yet occurred, it is unlikely to occur in the future. Unrealistic optimism also increases with the perceived preventability of a hazard and decreases with perceived frequency and personal experience. Questionnaire responses from teachers in a study by Weinstein (1988) reveal a strong tendency among subjects to believe that they would experience less difficulty than the average first-year teacher in 33 different teaching tasks. Studies have also been conducted on unrealistic optimism with regard to the likelihood of car accidents (Robertson, 1977; Rutter, Quine and Albery, 1998), the likelihood of lung cancer for smokers (Reppucci, Revenson, Aber and Reppucci, 1991), and the likelihood of getting divorced (Baker and Emery, 1993).

The classic study on unrealistic optimism was conducted by Weinstein (1980). In his study 258 students estimated how much their own chances of experiencing 42 events differed from the chances of their classmates. Overall, subjects rated their own chances to be above average for positive events and below average for negative events. Thus, the results indicate a clear differentiation between positive and negative events. Subjects expected good things to happen to them more often than to their peers, and bad things to happen to them less often. For instance, subjects thought themselves to be 41.5% more likely than their peers to earn a good starting salary, and 38.4% less likely to have a heart attack before the age of 40.

Optimism seems also to be linked to an illusion of control. Even for purely chance events, people sometimes show optimistic biases (Irwin, 1953; Langer and Roth, 1975; Marks, 1951). Not only do individuals consider themselves to be better than the average person, they also see themselves in a better light than others see them (Taylor and Brown, 1988). Individuals judge positive traits to be overwhelmingly more characteristic of self than negative attributes (Alicke, 1985; Brown, 1986). There is also empirical evidence indicating that positive personality information can be recalled much more quickly than negative information (Kuiper and Derry, 1982). Most people also show poorer recall for information related to failure than to success (Silverman, 1964), and tend to recall their task performance as more positive than it actually was (Crary, 1966). Individuals were also found to credit themselves for past success, and blame external factors for failures (Fischhoff, 1982; Langer and Roth, 1975).

1.3 Overconfidence and unrealistic optimism within the context of financial decision making

"The combination of overconfidence and optimism is a potent brew, which causes people to overestimate their knowledge, underestimate risks, and exaggerate their ability to control events" (Kahneman and Riepe, 1998, p. 54). Cornett, Mehran and Tehranian (1998) investigated whether financial markets are overly optimistic about the prospects of firms that issue equity. The authors compared the performance of all voluntary and all involuntary common stock offerings by publicly traded commercial banks in the U. S. during the period from June 1983 through December 1991, and observed that voluntary issuers earned significantly negative two-day abnormal returns on announcements of the issue, while involuntary issuers did not. Also, during the three years after the stock issue, the banks that voluntarily issued stock experienced an average matched adjusted return of - 14.44%. Because the firms generally experienced improvements in profitability prior to the offering, the market was overly optimistic about the prospects of the issuing firms. However, as market participants saw and evaluated the actual post-issue performance of the banks, they adjusted the stock price accordingly.

Odean (1999) analyzed trading records for 10,000 accounts at a large discount brokerage house. The results indicate that investors bought securities that have experienced greater absolute price changes over the previous two years than the ones they sold. They bought similar numbers of winners and losers, but they sold far more winners than losers. Thus, on average, the stocks investors purchased actually underperformed those they sold. It may be that those who bought previous winners believed that securities would follow trends, whereas those who bought previous losers believed they would revert. In addition, Odean (1999) showed that the observed trading volume, as implied by overconfidence, was excessive. Thus, investors clearly traded too much.

In a further study, Barber and Odean (2000) analyzed investment behavior of private households. The authors found that of 66,465 households with accounts at a large discount broker in the period from 1991 to 1996, those that traded most earned an annual return of 11.4%, while the market return was 17.9%. High turnover households underperformed the low turnover households. The excessive trading volume of the high turnover households cost them about 6.8% relative to the returns earned by low turnover households. In addition, the results indicate that the average household turns over about 75% of its common stock portfolio annually. Barber and Odean (2000) conjecture that the high trading volume is due to overconfidence. Overconfident investors are assumed to overestimate the value of their private information, and this causes them to trade too actively and, consequently, to earn below average returns.

Overconfidence has not only been investigated in field data, but has also been analytically modeled. Benos (1998), for instance, models overconfidence by assuming that some risk neutral investors overestimate the precision of their private information. These overconfident traders compete in market orders with another group of informed traders who have rational expectations. The results indicate that biased traders may make higher individual profits than traders with rational expectations. Overconfident traders were also found to increase market depth, price variability, informativeness, and trading volume in the presence of a risk neutral market maker.

In the model of Odean (1998), a market is examined in which price-taking traders, a strategic-trading insider, and risk-averse market makers are overconfident. Overconfidence is defined as the overestimation of the precision of private knowledge. The results indicate that overconfident traders increase trading volume and market depth, and lower their expected utilities. Overconfident traders hold undiversified portfolios. The effect of overconfidence on volatility and price quality depends on who in the market is overconfident. In addition, overconfident traders can cause the market to underreact to the information of rational traders. Gervais and Odean (1999) developed a multi-period market model that describes both the process by which traders learn about their ability, and how a bias in this learning *can* create overconfidence by causing traders to take too much credit for their successes. Success is measured by how well a trader forecasts dividends. The model predicts that overconfident traders will increase their trading volume and thereby lower their expected profits. Volatility increases with the number of past successes a trader has had. Investors are shown to be most overconfident early in their careers. With experience, self assessment becomes more realistic and overconfidence more subdued. In contrast to other models that assume that biased traders stay in the market by earning above-average returns, the model by Gervais and Odean (1999) is based on biased traders who earn, on average, lower profits. In their model, overconfidence does not lead to greater profits, but greater profits do lead to overconfidence.

The studies discussed above support the conjecture that overconfidence influences individual behavior in financial decision making. Empirical results indicate that individual investors overestimate the precision of private knowledge, generate confidence intervals which are too narrow, and are overly optimistic about future events, even uncontrollable ones. Markets were found to be overly optimistic about the prospects of firms that issued equity, and the trading volume of individual investors was found to be too high, leading to suboptimal net returns.

However, there are also studies which challenge the validity of the conclusion that individuals are *generally* overconfident. Erev, Wallsten and Budescu (1994) showed that both overconfidence as well as underconfidence can be obtained from the same set of data, indicating that the results are actually moderated by the research method used and thus are not a general phenomenon. Also the results of Juslin, Winman and Olsson (2000) indicate that the overconfidence bias depends on the selective attention to particular data sets. Klayman, Soll, Gonzalez-Vallejo and Barlas (1999) emphasize that overconfidence depends on (i) how the experimenter asks his/her questions, (ii) what he/she asks, and (iii) whom he/she asks. First, in studies that used two-choice questions, observed biases were few, whereas studies that used confidence-range judgments were found to trigger more overconfident responses. Second, no relation between the amount of overconfidence and the difficulty of the domain of the questions was observed. However, empirical evidence indicates that domains differ in the extent to which they elicit under- and overconfidence, respectively. Third, consistent individual differences in the degree of overconfidence were found, indicating that individuals generally differ in their proneness to biased responses.

2. Hypotheses

Overconfidence refers to the systematic overestimation of the accuracy of one's decisions, particularly to the overestimation of private information and knowledge. Empirical evidence indicates that overconfidence is more likely in diffuse tasks, for instance diagnosing illnesses which require making judgments under uncertainty, than in mechanical tasks, e.g. solving arithmetic problems (Einhorn, 1980). Thus, in the context of an experimental asset market, it is hypothesized that an individual who is predicting asset prices, a task which requires to make judgments under uncertainty, will be prone to overconfidence.

Hypothesis 1: Traders are overconfident with respect to the accuracy of their price predictions.

The overestimation of private information and individual knowledge also implies that subjective confidence intervals are too narrow. Subjective confidence intervals were found to exclude the correct answers too often, revealing individual overconfidence.

Hypothesis 2: Subjective confidence intervals are too narrow.

Empirical evidence also indicates that experts are more likely to be overconfident than relatively inexperienced individuals (Heath and Tversky, 1991). Thus, it is hypothesized that overconfidence will be particularly pronounced in late market periods, when traders have already gained experience, and that overconfidence will be lowest at the beginning of trading.

Hypothesis 3: The degree of overconfidence in price predictions is highest in late trading periods and lowest in early trading periods.

Individual traders with a high turnover of their portfolios were also found to perform poorer than those traders with a low turnorver (Barber and Odean, 2000). Thus, it is hypothesized that traders with an above-average trading volume will earn less on the experimental asset market than traders with a trading volume below-average.

Hypothesis 4: Individual earnings of those traders whose trading volume is above average fall short of earnings by traders whose trading volume is below average.

3. The experiment

3.1 Participants

Overall, 72 participants, all students either at the University of Vienna or at the Vienna University of Economics and Business Administration, participated in six experimental asset markets. Participants earned on average a remuneration of ATS 209.82, approximately $14 in May 2000 when the experiment was conducted, the standard deviation was ATS 161.93 (about $11). The time required to conduct the experiment was about 2 hours and 15 minutes. Twenty-one females and 51 males, aged 18 to 29 (M = 21.51, SD = 2.33), participated in the experiment. Fifty-nine participants were students of economics, whereas the remaining 13 participants were enrolled in other social science disciplines.

3.2 Experimental design

The experiment was conducted in a 2 x 3 factorial design in order to investigate the interaction of differently informed participants within *one* market. The independent variables were (i) dividend information (complete information about dividend payments, no information) and (ii) the public signal subjects received about the market participants' average price prediction (precise public signal, vague public signal, no public signal). Both variables were between-subjects factors.

Participants were randomly assigned to the experimental conditions. Half of the participants received complete information about the dividend distribution (market insiders), whereas the other market participants got no information (market outsiders).

In addition, participants received exactly one of three public signals: a precise public signal, a vague public signal, and no public signal. In the first condition (precise public signal), participants received information about their individual prediction of the average market price in the next trading period s_i and a precise public signal informing them about the corresponding average prediction of all market participants $\bar{s}_i$, including themselves ($\bar{s}_i = \sum_{i=1}^{n} s_i$).

In the second condition (vague public signal), participants also had information about their individual prediction of the average market price in the next trading period s_i, but obtained only a vague public signal $\hat{s}_i$, indicating current market mood on a seven-step scale, ranging from a very optimistic market mood to a very pessimistic market mood. The vague public signal $\hat{s}_i$ was defined as the relative deviation of one's individual price prediction s_i from the average prediction $\bar{s}_i$ ($\hat{s}_i = \frac{\bar{s}_i - s_i}{\bar{s}_i}$). If the individual price prediction was lower than the average price prediction, participants were informed that the market mood was optimistic. When individual price prediction was higher than the average price prediction, participants were informed that the market mood was pessimistic with respect to their own prediction (see Table 1).

Table 1: Market mood scale (vague public signal)

Relative deviation of subject's price prediction from the average price prediction $\hat{s}_i$	Market mood
$\hat{s}_i$ < - 0.49	Very pessimistic market mood
- 0.49 ≤ $\hat{s}_i$ < - 0.29	Pessimistic market mood
- 0.29 ≤ $\hat{s}_i$ < - 0.09	Slightly pessimistic market mood
- 0.09 ≤ $\hat{s}_i$ < 0.10	Sideward moving market mood
0.10 ≤ $\hat{s}_i$ < 0.30	Slightly optimistic market mood
0.30 ≤ $\hat{s}_i$ < 0.50	Optimistic market mood
$\hat{s}_i$ > 0.49	Very optimistic market mood

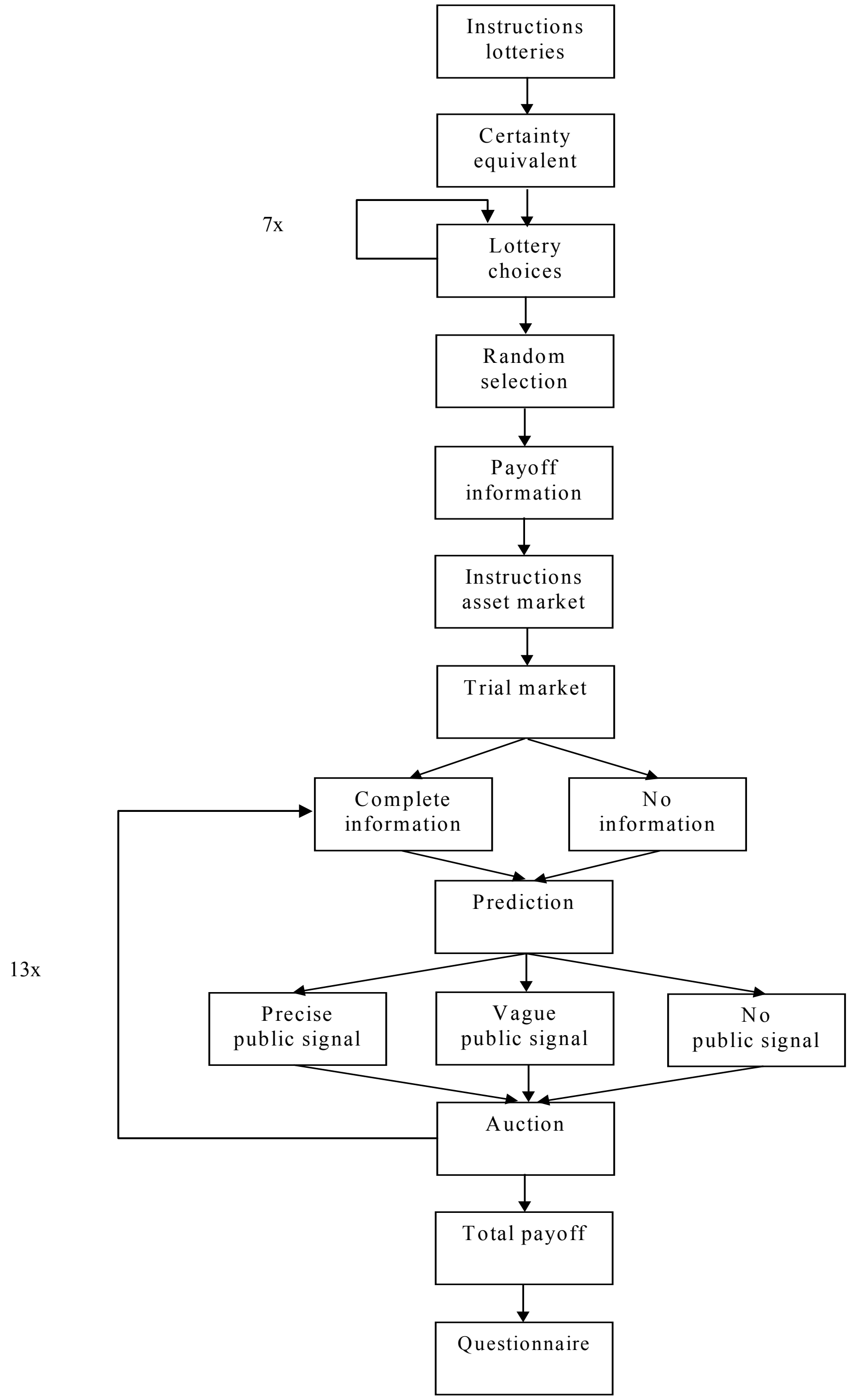
In the third condition (no public signal), participants received information only about their individual prediction of the average market price in the next trading period s_i, but no information about the predictions of the other market participants.

3.3 Experimental procedure

The experiment consisted of three phases. In the first phase, subjective propensity towards risk was measured experimentally by the methods of certainty equivalents and by lottery choices in order to control for differences in individual risk attitude. In the second phase, the experimental asset market was opened and assets were traded. In the third and last phase, participants were asked to fill out a short questionnaire. The complete experiment was conducted on computers and was programmed by z-Tree (Zurich Toolbox for Readymade Economic Experiments, Fischbacher, 1998). The exact sequence of events in the experiment is shown in Figure 1.

Phase 1: After brief instructions, participants were asked (i) to reveal their certainty equivalent for a lottery that offers a payoff of 100 Experimental Guilders with a probability of p = .50, and zero Experimental Guilders[1] otherwise; and (ii) to make seven decisions among risky lotteries. As a control for position effects, the lotteries were systematically varied.

Figure 1: The sequence of events in the experiment

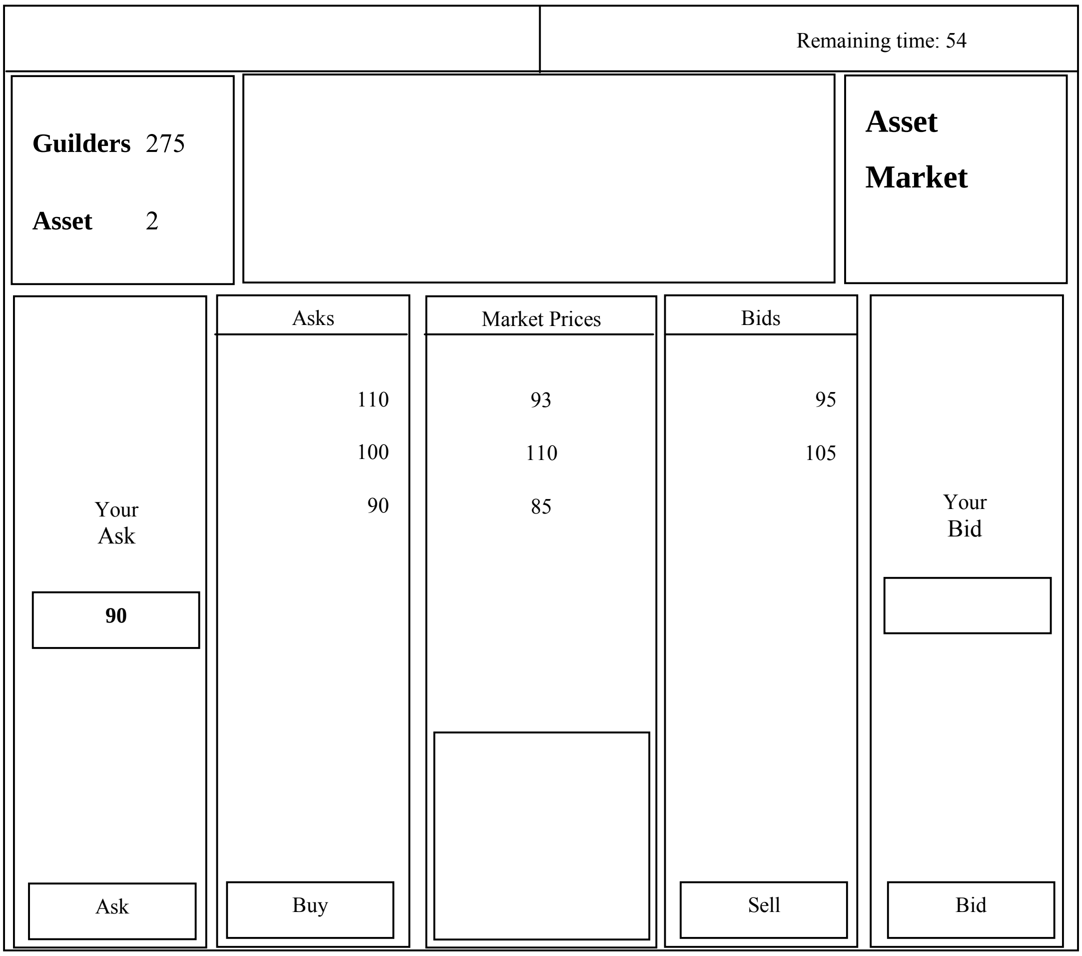


[1] The exchange rate for Experimental Guilders was 10 to 1, that is 10 Experimental Guilders equal 1 Austrian Schilling.

The certainty equivalent allows the experimenter to infer whether participants are risk averse, risk neutral, or risk seeking, whereas the lotteries were constructed in a way that allows the experimenter only to distinguish between risk aversion and risk neutrality. A certainty equivalent that is lower than the expected value of the lottery, which is 50 Experimental Guilders, indicates risk aversion, whereas a certainty equivalent equal to the expected value indicates risk neutrality, and finally a certainty equivalent above the expected value indicates risk seeking behavior. Also, the seven decisions among lotteries can be used to infer risk attitude. However, since each lottery has the same expected value in each of its two components, namely the certain payoff and the risky payoff, the design only allows to distinguish between risk aversion (certain payoff) and risk neutrality (risky payoff).

One of the seven decisions was randomly selected in order to determine the individual payoff, which was then added to the total payoff earned in the auction. The time required for conducting phase 1 was about 15 to 20 minutes.

Figure 2: The screen of the auction



Phase 2: After receiving instructions about the experimental asset market, subjects participated in two trial periods of six minutes in order to become familiar with the selling and buying procedures on the market. After the trial periods, the asset market was opened. Overall, six market sessions were run with 12 participants each on a computerized asset market (Zurich Toolbox for Readymade Economic Experiments, Fischbacher, 1998). The

computer screen for the auction is shown in Figure 2. Each market participant was entitled (i) to submit bids and asks, (ii) to accept standing bids and asks, whereas only improving offers, i.e. higher bids and lower asks, respectively, were allowed, or (iii) to stay aloof. Bids and asks were automatically ranked, indicating the most favorable offer. Information about trading history, provided as a chronological list of contracts, was common knowledge.

The experiment was performed as a continuous anonymous double auction. Participants were endowed with 250 Experimental Guilders plus five risky assets. Dividends were randomly determined according to p_d, and were paid out at the end of each period (see Table 2). In order to reveal possibly divergent dynamics in price and the intrinsic value of the asset, a monotonously falling expected value of the dividend was stipulated, implying consistently falling asset prices across trading periods. Participants were informed that the market would be open for at least 12 periods and at most 15 periods. The probability that the market would end after the 12th, 13th, and 14th period was 33%. Participants were also informed that at the end of the final market period the liquidation value of the asset would be zero. To ensure comparability between sessions, the last market period was randomly chosen once for all six sessions before the experiment was actually conducted. According to the random selection, it was determined that each session would end after the 13th period. Each period lasted for 180 seconds.

Table 2: Dividend payments in Experimental Guilders

Periods	Dividends	Probability (p_d)	Expected value
1-3	0, 11, 27, 45, 59	.20	28.40
4-6	0, 19, 35, 53	.25	26.75
7-9	0, 13, 21, 33, 49	.20	23.20
10-12	0, 11, 29, 43	.25	20.75
13	0, 7, 19, 27, 39	.20	18.40

Before the market was opened participants (i) either received information about the distribution of dividends in the next market period or received no such information, (ii) had to predict the next average market price, had to create a subjective confidence interval of 98% width, had to state how certain they were that their predictions were accurate on a nine-step scale, ranging from 1=not certain to 9=certain, and (iii) were given one of three public signals. The time required for conducting phase 2 was about 80 to 90 minutes.

Phase 3: Participants were asked to fill out a computerized post-experimental questionnaire with items designed to check how well they understood the experiment and to determine the effort they had put into arriving at accurate decisions. The time required for conducting phase 3 was about 15 to 20 minutes.

4. Experimental results

4.1 Descriptive data analysis

Participants earned on average 2,012.50 Experimental Guilders on the asset market (SD = 1,881.51), without the payoff of the lottery decisions. In each of the 13 market periods an average of 44.9 contracts were concluded by the groups of 12 market participants (SD = 15.07, ranging from a minimum of 7 contracts to a maximum of 89 contracts). The average market price was 79.94 Experimental Guilders (SD = 53.22).

As can be seen from Figure 3, the observed average market prices differed substantially from the expected market prices based on the intrinsic or fundamental value of the asset. However, over periods with increasing experience and learning, the observed average market prices came close to the expected prices. In period 9, the observed and the expected prices intersected, and for the next two trading periods the observed average trading prices overshot the expected ones. Prices were above the expected value, but then sharply decreased and tended to converge to the expected value again. Thus, the results on the average trading prices indicate - as in other experimental studies on trading behavior in asset markets - that with experience and repetition, learning takes place that ensures that market prices will converge to the equilibrium prediction (see e.g., Sunder, 1995).

Figure 3: Observed average market prices and expected market prices

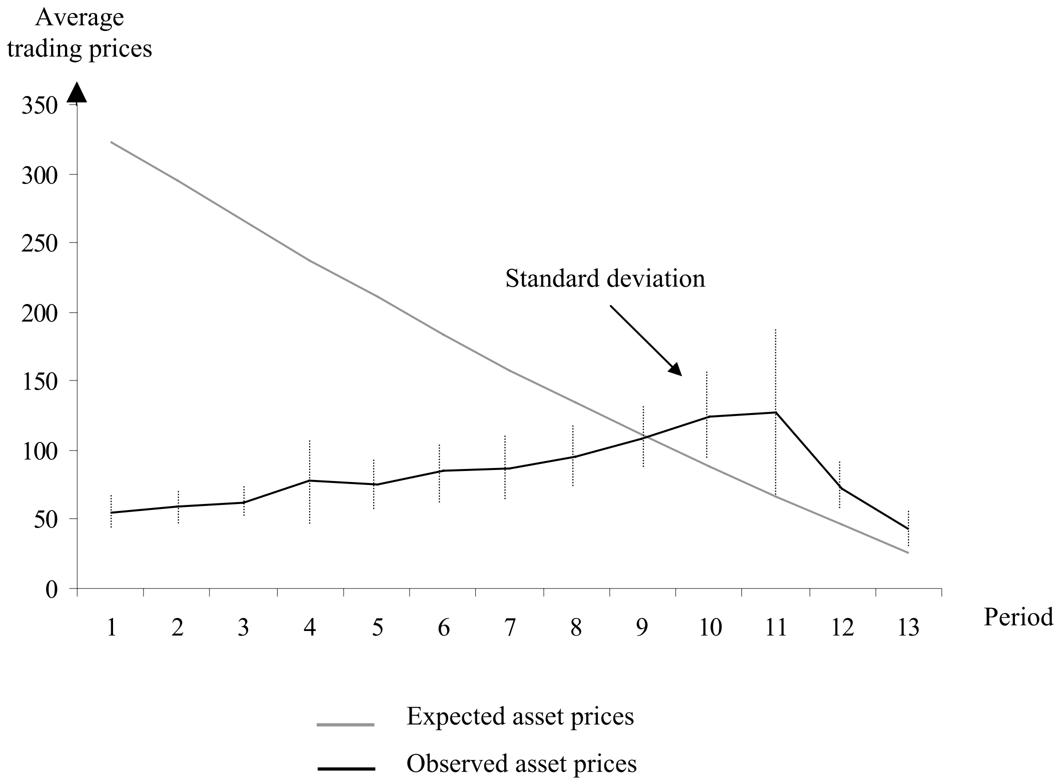
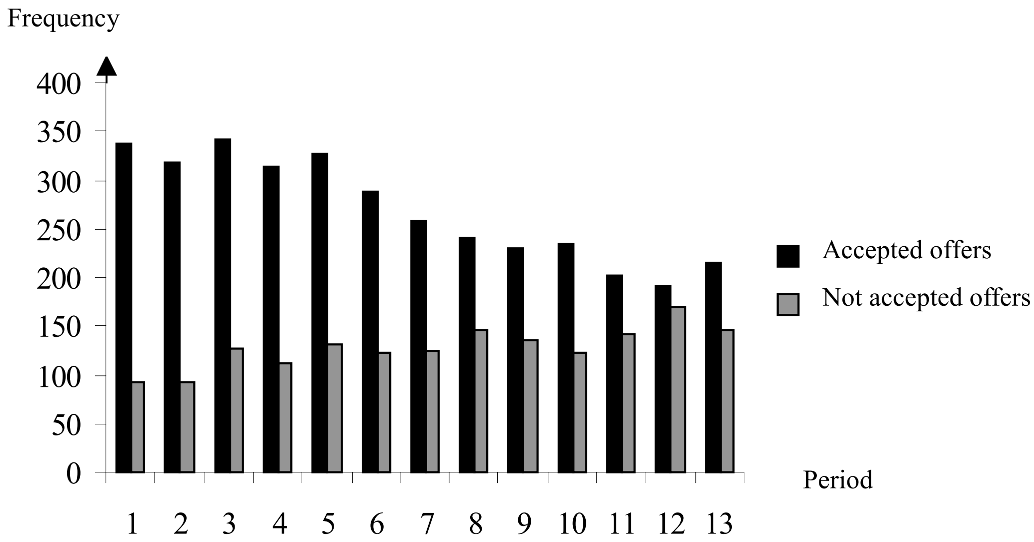


Figure 4 indicates that over the trading periods, the number of concluded contracts decreased (χ^2 = 129.16, p < .001), while the number of offers not accepted by other market participants increased (χ^2 = 43.69, p < .001). Whereas 78.37% of all submitted offers were accepted in the first trading period, only 53.04% of them were accepted in the 12th, and 59.50% were accepted in the 13th trading period by other market participants (χ^2 = 127.05, p < .001). Of course, one can argue that the number of accepted offers may have decreased because prices increased over trading periods. However, if one compares the average price of not accepted offers in period 1 with the corresponding price of not accepted offers in period 13, one can see that prices in fact decrease over time to a statistically significant degree (M_1 = 61.57, SD_1 = 34.11; M_{13} = 51.62, SD_{13} = 34.76; F(1; 460) = 6.13, p < .05), nevertheless the number of contracts concluded did not increase, but in fact decreased.

In a next step it was investigated whether individual risk attitude differs between sessions and between experimental conditions with respect to the elicitation method of certainty equivalents and with respect to the lottery decisions. The average certainty equivalent revealed by the participants was 43.42 (SD = 37.63), indicating a slight degree of risk aversion. Certainty equivalents did not differ significantly between the six sessions (F(5; 66) = 1.88, p = .11). An index for risk attitude ranging from 0=risk neutrality to 7=risk aversion was computed out of the seven decisions among lotteries. Subjects' average risk attitude amounted to 3.26 (SD = 1.91), indicating that in 3.26 cases the secure rather than the risky alternative in the lottery was chosen. Again no statistically significant difference between the six sessions was observed (F(5; 66) = 0.43, p = .83). Neither for the kind of public signal subjects received nor for the information condition was there a statistically significant difference between the groups with respect to the certainty equivalent (F(2; 69) = 2.26, p = .11; F(1; 70) = 2.40, p = .13) nor with respect to the lottery decisions (F(2; 69) = 0.36, p = .70; F(1; 70) = 2.42, p = .12). Thus, it can be expected that any differences observed in the experiment between experimental conditions are not caused by different underlying risk attitudes.

Figure 4: Frequency of accepted and not accepted offers across trading periods



Questionnaire data reveals that the subjects understood the instructions and that their decisions were well considered. Participants agreed to the statement that the instructions were clear and easy to understand (M = 7.11, SD = 2.24, all items are nine-step items ranging from 1=I do not agree to 9=I fully agree), and they also agreed that they had carefully considered their buying offers (M = 5.82, SD = 2.34) and their selling offers (M = 6.00, SD = 2.21).

4.2 Market price predictions

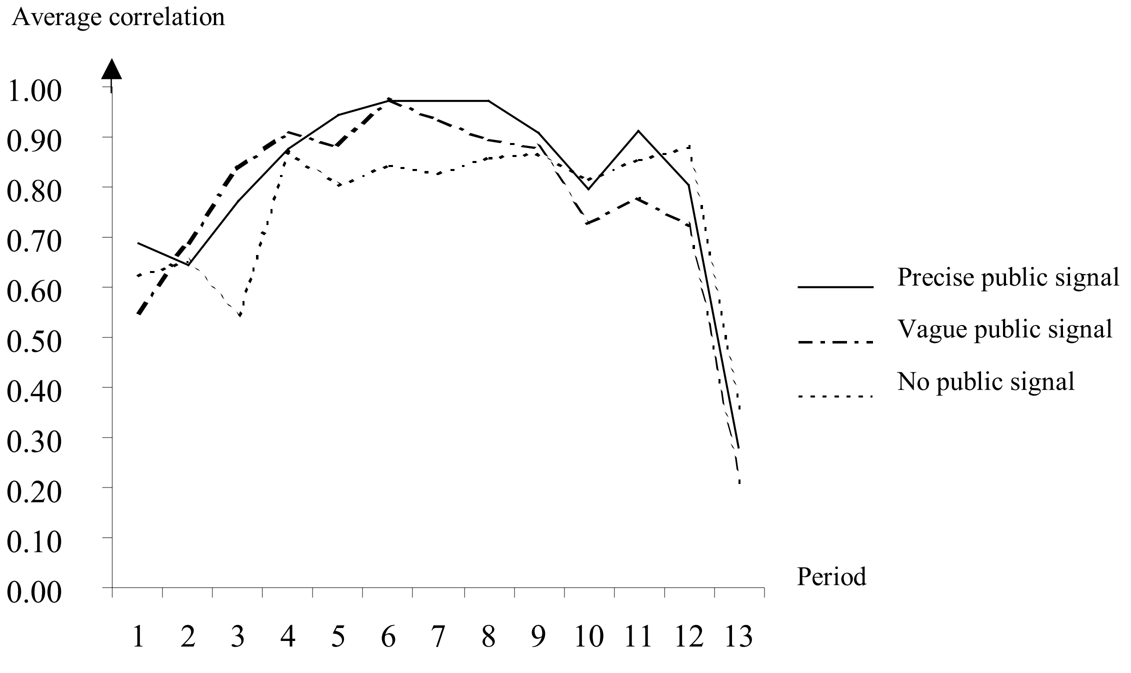
We hypothesized that traders on an experimental asset market would be overconfident with respect to the accuracy of their price predictions.

In each period before the market was opened, participants were asked to predict the next average trading price and to state how certain they were that their predictions would be accurate on a nine-step scale ranging from 1=not certain to 9=certain. It was expected that overconfidence would be less likely when a precise public signal had been issued, because in this circumstance uncertainty about the expectations of other market participants would be lowest. To the contrary, overconfidence should be more likely in condition three, because in this case uncertainty would be highest due to the fact that participants obtained no information at all about the predictions of others.

Figure 5 displays the average correlation between participants' price predictions and actual average trading prices across periods for each of the three experimental conditions, that is (i) for participants who received a precise public signal, (ii) for participants who received a vague public signal only indicating the market mood on a seven-step scale, and finally (iii) for participants who received no public signal at all.

Average correlations were z-transformed to enable the use of parametric statistical analyses. The results of an ANOVA showed that there is no statistically significant difference in accuracy between the three experimental conditions (M_p = .88, SD_p =.55; M_v = .82, SD_v = .55; M_n = .84; SD_n = .49; $F(2; 36) = 1.58$, $p = .22$). However, Figure 5 indicates that the accuracy of the predictions of those participants who received a precise public signal was slightly higher in the first trading period, but eventually information dissemination between the differently informed market participants took place, and differences with respect to the accuracy of the participants vanished.[2]

Figure 5: Average correlation between participants' predictions and actual trading prices for all experimental conditions



In general, the results indicate considerable learning effects across periods. Whereas in the first period the average trading price prediction correlated only in a mediocre way with actual average market prices ($r(72) = .62$, $p < .001$), the correlation gradually increased up to the

[2] Recent experimental analyses of information dissemination are provided by Kirchler, Maciejovsky and Weber (2001), Maciejovsky (2001) as well as by Maciejovsky, Helmenstein, Kirchler, Haumer and Hofmann (2001).

seventh period (r(72) = .91, p < .001), remained at a very high level until the twelfth period, and then as uncertainty about market duration came into play, sharply decreased from period 12 (r(72) = .88, p < .001) to period 13 (r(72) = .27, p < .05).

In a next step, the objective accuracy of the predictions was compared to the subjective certainty of having made accurate predictions. Responses on subjective certainty ranged from 1=not certain to 9=certain. In order to compare the correlations of the participants' price predictions and actual trading prices with their subjective certainty of having made accurate predictions, the scale was transformed so that responses ranged from 0=not certain to 1=certain.

Figure 6 indicates that across trading periods, the objective accuracy of participants' predictions increased, but then sharply declined from period 12 to period 13, whereas their subjective certainty of having made accurate predictions remained almost constant. Also, questionnaire results reveal that participants found it much more difficult to accurately predict the next average trading price in early trading periods (M = 4.75, SD = 2.44) than in later periods (M = 6.08, SD = 2.05; t = 2.99, p < .01), despite the uncertain ending of the market (nine-step scale ranging from 1=not easy to 9=easy).

Figure 6: Relationship between objective accuracy of participants' predictions and subjective certainty

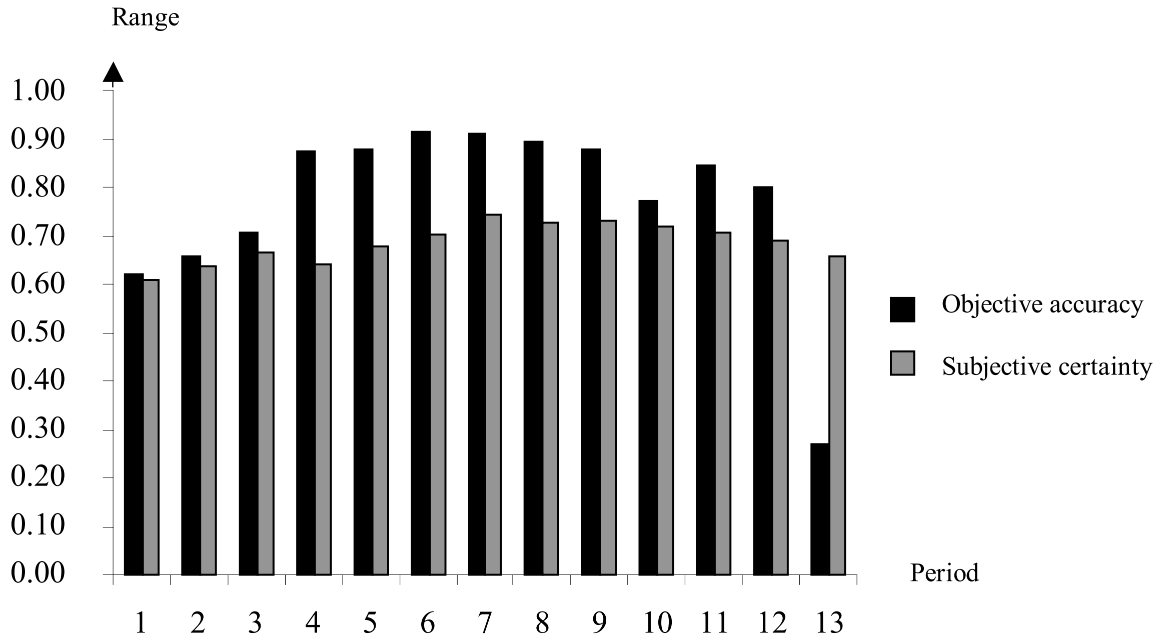


Figure 6 indicates that overconfidence seems not to be a generally valid phenomenon. Instead, participants were found to be well-calibrated in their subjective certainty of having made accurate predictions in the first three trading periods, underconfident from period four onwards, as the accuracy of participants' price predictions increased, whereas their subjective certainty remained almost constant, and overconfident from period 12 to period 13. The objective accuracy of participants' price predictions declined sharply in the last trading period. However, the subjective certainty of having made accurate predictions did not adjust correspondingly, indicating individual overconfidence with respect to participants' price predictions.

Thus, the results do not support hypothesis 1, because traders in this experiment were found not to be generally overconfident. However, in the last trading period, experienced traders were overconfident about the accuracy of their price predictions. Subjective certainty did not adjust to the objective accuracy of market participants' predictions. The kind of public signal participants received was irrelevant, indicating that information differences vanish in the course of trading. Formerly private information is revealed, and consequently becomes public information.

4.3 Subjective confidence intervals

We also hypothesized that (i) generated subjective confidence intervals would be too narrow, and that (ii) the degree of overconfidence in price predictions would be highest in late trading periods, and lowest in early trading periods.

First it was investigated whether the generated subjective confidence intervals covered the predicted range of 98%. In each period, participants were asked to make price predictions that (i) *would not* be exceeded with a probability of 99% (upper boundary) and that (ii) *would be* exceeded with a probability of 99% (lower boundary). Instead of the expected range of 98 percent for the confidence intervals, the observed subjective confidence intervals covered only a range of 74%. Figure 7 displays the frequency of instances where the observed average trading prices lay outside the generated confidence intervals.

Figure 7: Frequency of confidence intervals of insufficient width with respect to the upper and lower boundary

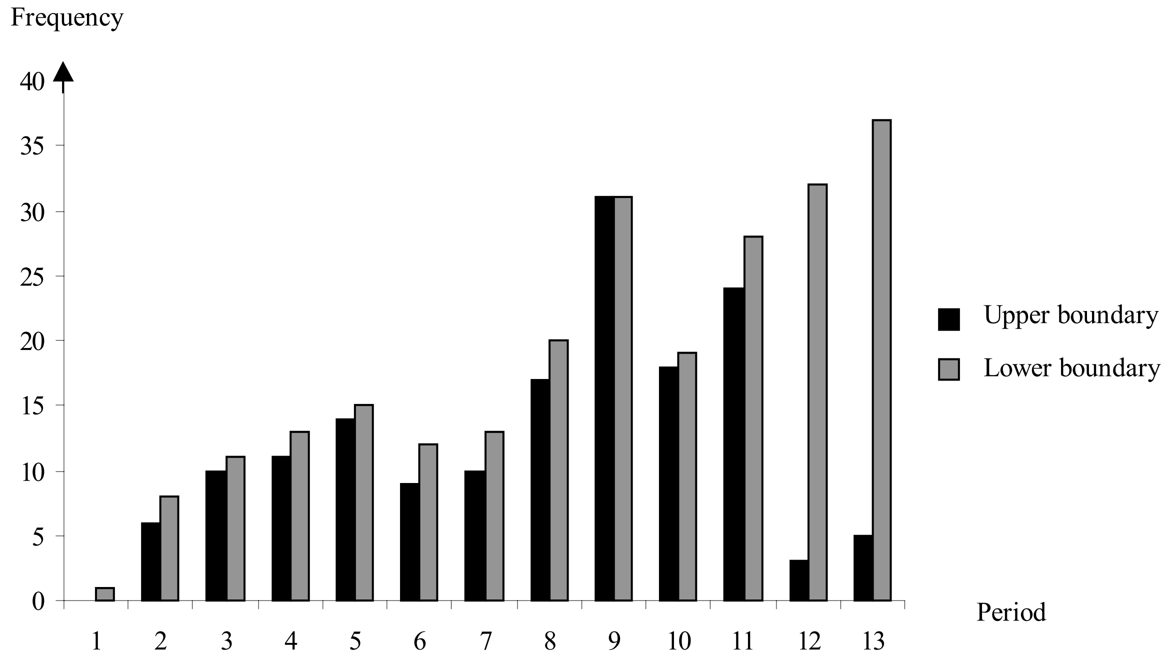


Figure 7 indicates that especially in late trading periods when uncertainty about market duration came into play, there was an increased frequency of confidence intervals that did not cover the required range of average trading prices. Moreover, subjective confidence intervals were not adjusted with respect to the lower boundary. As market prices declined, subjective confidence intervals were not sufficiently adjusted. Under complete uncertainty, i.e. in the first trading periods, confidence intervals were quite accurate. However, with increasing experience participants relied too heavily on their subjective price predictions, causing their confidence intervals to narrow. Thus, hypotheses 2 and 3 were both confirmed. Participants were found to generate confidence intervals that are not wide enough, and the degree of overconfidence was found to be highest in late market periods when participants were already experienced.

4.4 Trading volume and individual earnings

We hypothesized that individual earnings of those traders whose trading volume was above average would fall short of earnings by traders whose trading volume was below average.

A median-split was computed in order to test our hypothesis. The results indicate that individual earnings by those market participants whose trading volume was above average were not statistically significantly lower than earnings by participants whose trading volume was below average (M_A = 2,122.11, SD_A = 2,036.09; M_B = 1,942.75, SD_B = 1,797.10; $F(1; 70) = 0.15$, $p = .70$).[3] Thus, we cannot reject the null hypothesis indicating that individual earnings do not differ with respect to trading volume. The results do not support hypothesis 4. However, we found that overconfidence, measured with respect to subjective confidence intervals, was negatively correlated with individual earnings, indicating that the higher the degree of overconfidence the lower individual earnings ($r(72) = -.24$, $p < .05$).

Additionally, when only those contracts are analyzed that are based on participants' own offers submitted to the market, participants with an above-average trading volume earned statistically significantly more than participants with a below-average trading volume (M_A = 2,477.92, SD_A = 2,288.45; M_B = 1,547.08, SD_B = 1,224.31; $F(1; 70) = 4.63$, $p < .05$). Thus, our results do not support the empirical findings of Barber and Odean (2000) who report that a highly active trading strategy with an above-average trading volume reduces individual earnings. In our experiment participants with a net-surplus of buying contracts (a higher buying than selling activity) earned statistically significantly more on the market than those participants with a net-surplus of selling contracts (M_B = 2,779.50, SD_B = 2,439.68; M_S = 1,578.98, SD_S = 1,321.73; $F(1; 70) = 7.37$, $p < .001$).

5. Discussion

Our results indicate that traders on the experimental asset market were not *generally* prone to overconfidence. The existence of overconfidence as well as the degree of overconfidence was found to be moderated by the methodology used. These findings correspond to the results of Erev, Wallsten and Budescu (1994) as well as to Klayman, Soll, Gonzalez-Vallejo and Barlas (1999) and are of particular interest to formal analyses of overconfidence, because some of the models assume a constant and stable individual predisposition of overconfidence (Benos, 1998; Odean, 1998), whereas others take into account individual learning (e.g., Gervais and Odean, 1999).

---

[3] For comparison a buy-and-hold strategy guaranteed market participants on average earnings of 1,762.50 Experimental Guilders.

In our experiment, participants were well-calibrated in their certainty of having made accurate price predictions during some trading periods, whereas during other trading periods participants were found to be underconfident as well as overconfident. Particularly, participants overestimated the precision of their predictions in late trading periods, when uncertainty about market duration was important. Although the accuracy of their market price predictions sharply declined in the last trading period, their subjective certainty of having made accurate predictions did not decline to an equal extent.

In addition, we found that subjective confidence intervals were not calibrated accurately, they were far too narrow. In late trading periods in particular, participants did not adjust their subjective confidence intervals to the lower boundary of their predictions. As market prices declined, participants failed to adjust their confidence intervals in an equal manner. It was also shown that under complete uncertainty in early trading periods with inexperienced traders, confidence intervals were quite accurate, however in line with Heath and Tversky (1991), with increasing experience, market participants relied too heavily on their subjective price predictions and exhibited overconfidence. In contrast to the predictions of the model by Gervais and Odean (1999) we thus found that overconfidence increases – and not declines - with experience.

The kind of public signal participants received proved to be irrelevant, indicating that differences in the degree of information vanishes in the course of trading. Formerly private information is revealed when offers are submitted and when contracts are concluded, and becomes public information in the process. Individual earnings by those market participants with an above-average trading volume were not found to be substantially lower than earnings by traders with a below-average trading volume as predicted theoretically by Odean (1998) and as was shown empirically by Barber and Odean (2000). To the contrary, our results indicate that when only those contracts are analyzed that are based on participants' own offers submitted to the market, participants with an above-average trading volume earned statistically significantly more than participants with a below-average trading volume. Additionally, we found that overconfidence with respect to subjective confidence intervals was negatively correlated with individual earnings, indicating that the higher the degree of overconfidence was, the lower individual earnings have been.

References

Alicke, M. D. 1985. Global self-evaluation as determined by the desirability and controllability of trait adjectives. *Journal of Personality and Social Psychology*, 49, 1621-1630.

Babad, E. 1987. Wishful thinking and objectivity among sports fans. *Social Behavior*, 4, 231-240.

Baker, L. A. and Emery, R. E. 1993. When every relationship is above average: Perceptions and expectations of divorce at the time of marriage. *Law and Human Behavior*, 17, 439-450.

Barber, B. M. and Odean, T. 2000. Trading is hazardous to your wealth: Common stock investment performance of individual investors. *Journal of Finance*, 55, 773-806.

Benos, A. V. 1998. Aggressiveness and survival of overconfident traders. *Journal of Financial Markets*, 1, 353-383.

Bornstein, B. H. and Zickafoose, D. J. 1999. „I know I know it, I know I saw it“: The stability of the confidence-accuracy relationship across domains. *Journal of Experimental Psychology: Applied*, 5, 76-88.

Brenner, L. A., Koehler, D. J., Liberman, V. and Tversky, A. 1996. Overconfidence in probability and frequency judgments: A critical examination. *Organizational Behavior and Human Decision Processes*, 65, 212-219.

Brown, J. D. 1986. Evaluations of self and others. Self-enhancement biases in social judgments. *Social Cognition*, 4, 353-376.

Christensen-Szalanski, J. J. and Bushyhead, J. B. 1981. Physicians’ use of probabilistic information in a real clinical setting. *Journal of Experimental Psychology: Human Perception and Performance*, 7, 928-935.

Cooper, A. C., Woo, C. Y. and Dunkelberg, W. C. 1988. Entrepreneurs’ perceived chances of success. *Journal of Business Venturing*, 3, 97-108.

Cornett, M. M., Mehran, H. and Tehranian, H. 1998. Are financial markets overly optimistic about the prospects of firms that issue equity? Evidence from voluntary versus involuntary equity issuances by banks. *Journal of Finance*, 53, 2139-2159.

Crary, W. G. 1966. Reactions to incongruent self-experiences. *Journal of Consulting Psychology*, 30, 246-252.

De Bondt, W. F. M. and Thaler, R. H. 1995. Financial decision-making in markets and firms: A behavioral perspective. In: R. Jarrow, A. Jarrow, V. Maksimovic and W. T. Ziemba (eds.). *Finance. Handbooks in Operations Research and Management Science 9*. Amsterdam: North Holland. (pp. 385-410).

Dowie, J. 1976. On the efficiency and equity of betting markets. *Economica*, 43, 139-150.

Einhorn, H. J. 1980. Overconfidence in judgment. *New Directions for Methodology of Social and Behavioral Science*, 4, 1-16.

Erev, I., Wallsten, T. S. and Budescu, D. V. 1994. Simultaneous over- and underconfidence: The role of error in judgment processes. *Psychological Review*, 101, 519-528.

Ferrell, W. R. 1994. Discrete subjective probabilities and decision analysis: Elicitation, calibration and combination. In: G. Wright and P. Ayton (eds.). *Subjective Probability*. Chichester: Wiley. (pp. 411-451).

Fischbacher, U. 1998. *Zurich Toolbox for Readymade Economic Experiments. Experimenter's Manual.* University of Zurich.

Fischhoff, B. 1982. For those condemned to study the past: Heuristics and biases in hindsight. In: D. Kahneman, P. Slovic, and A. Tversky (eds.). *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press.

Fischhoff, B., Slovic, P. and Lichtenstein, S. 1977. Knowing with certainty: The appropriateness of extreme confidence. *Journal of Experimental Psychology*, 3, 552-564.

Frank, J. D. 1935. Some psychological determinants of the level of aspiration. *American Journal of Psychology*, 47, 285-293.

Gervais, S. and Odean, T. 1999. Learning to be overconfident. *Working Paper*. University of California at Davis.

Gigerenzer, G., Hoffrage, U. and Kleinbölting, H. 1991. Probabilistic mental models: A Brunswikian theory of confidence. *Psychological Review*, 98, 506-528.

Griffin, D. and Tversky, A. 1992. The weighing of evidence and the determinants of confidence. *Cognitive Psychology*, 24, 411-435.

Hausch, D. B., Ziemba, W. T. and Rubinstein, M. 1981. Efficiency of the market for racetrack betting. *Management Science*, 27, 1435-1452.

Heath, C. and Tversky, A. 1991. Preference and belief: Ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty*, 4, 5-28.

Hoch, S. J. 1985. Counterfactual reasoning and accuracy in predicting personal events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 11, 719-731.

Irwin, F. W. 1953. Stated expectations as functions of probability and desirability of outcomes. *Journal of Personality*, 21, 329-335.

Juslin, P. 1993. An explanation of the hard-easy effect in studies of realism of confidence in one's general knowledge. *European Journal of Cognitive Psychology*, 5, 55-71.

Juslin, P. 1994. The overconfidence phenomenon as a consequence of informal experimenter-guided selection of almanac items. *Organizational Behavior and Human Decision Processes*, 57, 226-246.

Juslin, P., Winman, A. and Olsson, H. 2000. Naive empiricism and dogmatism in confidence research: A critical examination of the hard-easy effect. *Psychological Review*, 107, 384-396.

Kahneman, D. and Riepe, M. W. 1998. Aspects of investor psychology. *Journal of Portfolio Management*, 24, 52-65.

Keren, G. B. 1987. Facing uncertainty in the game of bridge: A calibration study. *Organizational Behavior and Human Decision Processes*, 39, 98-114.

Kidd, J. B. 1970. The utilization of subjective probabilities in production planning. *Acta Psychologica*, 34, 338-347.

Kirchler, E., Maciejovsky, B. and Weber, M. 2001. Framing effects on asset markets: An experimental analysis. *Discussion Paper 17*, SFB-373, Humboldt-University of Berlin, Germany.

Klayman, J. 1995. Varieties of confirmation bias. In: J. Busemeyer, R. Hastie and D. L. Medin (eds.). *Psychology of Learning and Motivation. Decision Making from a Cognitive Perspective*. Vol. 32. New York: Academic Press. (pp. 365-418).

Klayman, J., Soll, J. B., Gonzalez-Vallejo, C. and Barlas, S. 1999. Overconfidence: It depends on how, what, and whom you ask. *Organizational Behavior and Human Decision Processes*, 79, 216-247.

Koriat, A., Lichtenstein, S. and Fischhoff, B. 1980. Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory*, 6, 107-118.

Kuiper, N. A. and Derry, P. A. 1982. Depressed and nondepressed content self-reference in mild depression. *Journal of Personality*, 50, 67-79.

Kunda, Z. 1990. The case for motivated reasoning. *Psychological Bulletin*, 108, 480-498.

Langer, E. J. 1975. The illusion of control. *Journal of Personality and Social Psychology*, 32, 311-328.

Langer, E. J. and Roth, J. 1975. Heads I win, tails it's chance: The illusion of control as a function of the sequence of outcomes in a purely chance task. *Journal of Personality and Social Psychology*, 32, 951-955.

Larrick, R. P. 1993. Motivational factors in decision theories: The role of self-protection. *Psychological Bulletin*, 113, 440-450.

Lichtenstein, S., Fischhoff, B. and Phillips, L. 1982. Calibration of probabilities: The state of the art to 1980. In: D. Kahneman, P. Slovic and A. Tversky (eds*.). Judgment Under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press.

Maciejovsky, B. 2001. An experimental analysis of differently informed traders interacting within one asset market. *Discussion Paper*, Humboldt-University of Berlin, Germany.

Maciejovsky, B., Helmenstein, C., Kirchler, E., Haumer, H. and Hofmann, E. 2001. Information dissemination on an experimental asset market with completely, optimistically, pessimistically, and uninformed traders. *Discussion Paper*, Humboldt-University of Berlin, Germany.

Marks, R. 1951. The effect of probability, desirability, and "privilege" on the stated expectations of children. *Journal of Personality*, 19, 332-351.

Murphy, A. H. and Winkler, R. L. 1984. Probability forecasting in meteorology. *Journal of the American Statistical Association*, 79, 489-500.

Neale, M. A. and Bazerman, M. H. 1990. *Cognition and Rationality in Negotiation*. The Free Press: New York.

Odean, T. 1998. Volume, volatility, price, and profit when all traders are above average. *Journal of Finance*, 53, 1887-1934.

Odean, T. 1999. Do investors trade too much? *American Economic Review*, 89, 1279-1298.

Oskamp, S. 1965. Overconfidence in case-study judgments. *Journal of Consulting and Clinical Psychology*, 29, 261-265.

Perfect, T. J. and Hollins, T. S. 1996. Predicting feeling of knowing judgments and postdicting confidence judgments in eyewitness memory and general knowledge. *Applied Cognitive Psychology*, 10, 371-382.

Plous, S. 1995. A comparison of strategies for reducing interval overconfidence in group judgments. *Journal of Applied Psychology*, 80, 443-454.

Pulford, B. D. and Colman, A. M. 1997. Overconfidence: Feedback and item difficulty effects. *Personality and Individual Differences*, 23, 125-133.

Reppucci, J. D., Revenson, T. A., Aber, M. and Reppucci, N. D. 1991. Unrealistic optimism among adolescent smokers and nonsmokers. *Journal of Primary Prevention*, 11, 227-236.

Robertson, L. S. 1977. Car crashes: Perceived vulnerability and willingness to pay for crash protection. *Journal of Community Health*, 3, 136-141.

Russo, J. E. and Schoemaker, P. J. H. 1992. Managing overconfidence. *Sloan Management Review*, 33, 7-17.

Rutter, D. R., Quine, L. and Albery, I. P. 1998. Perceptions of risk in motorcyclists: Unrealistic optimism, relative realism and predictions of behaviour. *British Journal of Psychology*, 89, 681-696.

Schraw, G. R. and Roedel, T. D. 1994. Test difficulty and judgment bias. *Memory and Cognition*, 22, 63-69.

Silverman, I. 1964. Self-esteem and differential responsiveness to success and failure. *Journal of Abnormal and Social Psychology*, 69, 115-119.

Soll, J. B. 1996. Determinants of overconfidence and miscalibration: the roles of random error and ecological structure. *Organizational Behavior and Human Decision Processes*, 58, 203-213.

Stael von Holstein, C.-A. S. 1972. Probabilistic forecasting: An experiment related to the stock market. *Organizational Behavior and Human Performance*, 8, 139-158.

Stone, D. N. 1994. Overconfidence in initial self-efficacy judgments: Effects on decision processes and performance. *Organizational Behavior and Human Decision Processes*, 59, 452-474.

Subbotin, V. 1996. Outcome feedback effects on under- and overconfident judgments (general knowledge tasks). *Organizational Behavior and Human Decision Processes*, 66, 268-276.

Sunder, S. 1995. Experimental asset markets: A survey. In: J. H. Kagel and A. E. Roth (eds.). *Handbook of Experimental Economics*. Princeton: Princeton University Press.

Taylor, S. E. and Brown, J. D. 1988. Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, 103, 193-210.

Wagenaar, W. and Keren, G. B. 1986. Does the expert know? The reliability of predictions and confidence ratings of experts. In: E. Hollnagel, G. Mancini and D. D. Woods (eds.). *Intelligent Decision Support in Process Environments*. Berlin et al.: Springer.

Weinstein, C. S. 1988. Preservice teachers' expectations about the first year of teaching. *Teaching and Teacher Education*, 4, 31-40.

Weinstein, N. D. 1980. Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, 39, 806-820.

Weinstein, N. D. 1984. Why it won't happen to me: Perceptions of risk factors and susceptibility. *Health Psychology*, 3, 431-457.

Weinstein, N. D. 1987. Unrealistic optimism about susceptibility to health problems: Conclusions from a community-wide sample. *Journal of Behavioral Medicine*, 10, 481-500.

West, R. F. and Stanovich, K. E. 1997. The domain specificity and generality of overconfidence: Individual differences in performance estimation bias. *Psychonomic Bulletin and Review*, 4, 387-392.

Yaniv, I. and Foster, D. P. 1997. Precision and accuracy of judgmental estimation. *Journal of Behavioral Decision Making*, 10, 21-32.

Yates, J. F. 1990. *Judgment and Decision Making*. Englewood Cliffs: Prentice-Hall.